Responses of Nutrient Efficient Maize Genotypes to Bio-fertilizer at Low Chemical Fertilizer Doses

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Abstract

High dose of chemical fertilizer is usually required to obtain high maize (*Zea mays* L.) yield. Bio-fertilizer application in combination with nutrient efficient genotype was expected to reduce the chemical fertilizer need without reducing the yield. The objective of the research was to evaluate the responses of nutrient efficient genotypes to bio-fertilizer at low chemical fertilizer doses. The field experiment was conducted at Agro Techno Park (ATP), South Sumatra. The treatments were arranged in Split-Split-Plot Design with three replications. The main plots were chemical fertilizer doses, which were 25, 50, and 100 % of standard dose at ATP (400, 100, and 50 kg ha^{-1} Urea, SP-36, and KCl, respectively). The sub-plots were nutrient efficient genotypes (B41, L167, and S219), and hybrid B 816 as comparison. The sub-sub-plots consisted of treatments with or without bio-fertilizers. The bio-fertilizer (10 ml L^{-1}) was sprayed to the soil around the plants at 2, 4, 6, and 8 weeks after sowing. The yields of nutrient efficient genotypes (5.23 to 7.89 ton ha^{-1}) were comparable to the yield of B 816 (6.58 to 7.62 ton ha^{-1}) at all chemical fertilizer doses without bio-fertilizer. The genotypes responded differently to the bio-fertilizer application. Supply of bio-fertilizer at chemical fertilizer doses of 50 % tended to increase the yield of B 41 up to 16 % of its yield at 100 % chemical fertilizer dose without bio–fertilizer. This suggested that the chemical fertilizer dose can be reduced by 50 % only for B 41.

Key words: bio-fertilizer, low input, maize, nutrient efficiency

Introduction

High dose of chemical fertilizer is usually required to obtain high maize yield, especially for South Sumatra soil with deficiency of macro elements problem due to low soil pH (< 5.6). However, poor farmers often cannot afford it. According to Djafar and Halimi (1998), the farmers in South Sumatra only apply the chemical fertilizer with sub optimum rate for maize production (75, 50, and 50 kg ha^{-1} Urea, SP 36, and KCl, respectively). An excessive use of chemical fertilizer can also cause an environmental problem. Nutrient efficient maize genotype in combination with bio-fertilizer may offer an alternative to overcome the problem.

Nutrient efficient genotype has the ability to produce a higher yield than other genotypes under low nutrient supply (Presterl *et al*., 2003; Worku *et al.*, 2007). Department Agronomy, Sriwijaya University is now in the process of developing the nutrient efficient open pollinated maize genotypes and B 41, S 219, and L 164 used in this experiment are some of them (Munandar *et al.*, 2010).

Bio-fertilizer usually contains microorganisms having specific function such as *Azospirillum* to fix N2 and P solubilizing bacteria to solubilize P from the soil and fertilizer to be available to the plants (Saraswati & Sumarno, 2008). Several researchers had conducted the experiments to evaluate the responses of various plants such as young Robusta coffee (Junaedi et al., 1999), soybean (Noor, 2003; Totok & Rahayu, 2007), and turfgrass (Guntoro et al., 2007) to the bio-fertilizer application, but the results were still inconsistent. Further research is still needed in this area.

Bio-fertilizer application in combination with nutrient efficient genotypes in this research was expected to reduce the chemical fertilizer supply up to 25% of the standard dose without reducing yield. The objective was to evaluate the responses of several nutrient efficient genotypes compared to the hybrid to bio-fertilizer application especially at low chemical fertilizer rate.

Materials and Methods

The experiment was conducted at Agro Techno Park (ATP), South Sumatra in January to April 2011. The soil was dominated by sand (69.91%) with 4.4 pH, 28.3 g kg^{-1} C organic matter, 2.1 g kg^{-1} N, 59.1 mg kg^{-1} P-Bray, and 0.19 c mol kg^{-1} exchangeable K. The experimental design was Split-split-Plot with three replications. The main plot, the chemical fertilizer doses, consisted of 25, 50, and 100 % of the standard rate at ATP (400, 100, and 50 kg ha^{-1} Urea, SP 36, and KCl, respectively). The split plot was the genotypes which consisted of B 41, S 219, and L164 as the nutrient efficient genotypes and Hybrid B 816 as comparison. The split-split plots were treatments with and without bio fertilizers which consisted of two types, Subur (bio fertilizer 1), and EM 4 (bio fertilizer 2). Seeds were sown manually with 70 cm x 25 cm row spacing and two seeds per hole. Plants were thinned into one plant per hole at one week after sowing (WAS), so in each 2.8 m x 2.5 m sub-sub plot contained 40 plants. Chemical fertilizers (1/3 of Urea, SP 36, and KCl) were applied at sowing and the rest of Urea was applied at 4 WAS. Organic fertilizer (10 ton ha^{-1}) was applied at 2 WAS. Bio-fertilizer (10 ml L^{-1}) was sprayed to the soil at 2, 4, 6, and 8 WAS as recommended application time. Water was sprayed to the soil around the plants for treatment without bio- fertilizer.

All ears of each sub-sub-plot were harvested at harvest maturity, counted, and air dried in the drying room for two weeks, weighted .and converted into yield (ton ha^{-1}). Ears from three sample plants (randomly chosen) per plot were weighted and the average was used to get the ear weight per plant data.

Results and Discussion

The yield of nutrient efficient genotypes (B 41, S 219, and L 164) at all chemical fertilizer doses without bio-fertilizer (5.23 to 7.89 ton ha^{-1}) was comparable to the yield of hybrid B 816 (6.58 to 7.62 ton ha^{-1}). Among the nutrient efficient genotypes, S 219 had the lowest yield followed by B 41 and L 164 genotypes, especially at 25 and 50% chemical doses (Table 1). This suggested that L 164 genotype in this experiment had the highest nutrient use efficiency compared to B 41 and S 219 genotypes. The result was consistent with the previous experiment (Munandar et al., 2010). The yield or ear weight (ton ha^{-1}) significantly correlated with ear weight $plant^{-1}$ ($r = 0.54^*$).

Bio-fertilizer application had no significant effect on yield (data not presented), but tended to increase yield only for B 41 and S 219 genotypes especially for Bio-fertilizer 1 (Table 1). The yield of B 41 at 50 % chemical fertilizer dose was 94 % of its own yield at 100 % chemical fertilizer rate without bio-fertilizer. The yield of B 41 genotype increased only 16 % by the application of Bio-fertilizer 1 or 9 % by bio-fertilizer 2 (Table 1). The yield of S 219 genotype increased 8 to 11 % at 25 and 50 % chemical fertilizer dose, respectively, but the values after the addition of bio-fertilizers were still lower than the yield at 100 % chemical fertilizer dose without bio-fertilizer. The data suggests that the chemical fertilizer dose can be reduced by 50 % with the application of bio-fertilizer only for B 41 genotype. The effect of genotype on yield was higher than the bio-fertilizer (data not presented).

The L 164 genotype and hybrid B 816 did not give positive responses to both bio-fertilizers probably because their yields at all chemical fertilizer doses without bio-fertilizer were higher than the yields of B 41 and S 219. It indicated that L 164 genotype and hybrid B 816 had an ability to take up or use nutrient more efficient than that of the B 41 and S 219 genotypes as suggested by Worku *et al*.(2007).

The bio-fertilizers used in this experiment contained microorganisms to fix N_2 and to solubilize P, but the P Bray of the soil was high. Therefore, small increase in yield of B 41 and S 219 genotypes by application of bio-fertilizer probably related to a better N use efficiency than P efficiency of the genotypes.

In conclusion, genotypes responded differently to the bio-fertilizers. Supply of bio-fertilizer at 50% of chemical fertilizer doses tended to increase the yield of B 41 genotype up to 16% of 100% chemical fertilizer dose without bio-fertilizer. This suggested that the chemical fertilizer dose can be reduced by 50% without reducing yield only for B 41 genotype.

Table 1. Yield (ear weight) of the nutrient efficient and hybrid genotypes as affected by bio and chemical fertilizers

Genotypes	Chemical Fertilizer (% of standard rate) ton ha^{-1}			mean
	25	50	100	
B 41 without biofertilizer	6.35 (101)	5.94 (94)	6.32 (100)	6.20
+ Bio fertilizer 1	5.84 (92)	6.96 (110)	6.89 (109)	6.56
+ Bio fertilizer 2	6.40 (101)	6.48 (103)	6.66 (105)	6.51
S 219 without biofertilizer	5.23 (79)	5.49 (83)	6.61 (100)	5.78
+ Bio fertilizer 1	5.74 (87)	6.22 (94)	6.58 (100)	6.18
+ Bio fertilizer 2	4.48 (68)	5.92 (90)	6.60 (100)	5.67
L 164 without biofertilizer	7.12	6.83	7.89	7.28
+ Bio fertilizer 1	6.37	6.23	7.44	6.68
+ Bio fertilizer 2	5.94	6.53	7.06	6.51
Hybrid B 816 without bioertilizer	6.58	7.62	7.19	7.13
+ Bio fertilizer 1	6.25	6.36	6.38	6.33
+ Bio fertilizer 2	6.03	7.05	6.83	6.64

Note: Number in parentheses is the relative to its yield at 100 % without bio-fertilizer

References

Djafar, Z.R., and E.S. Halimi. 1998. Increasing the corn production in South Sumatra. *J Tan Tropika*. 1:128-134.

Guntoro, D., B.S. Purwoko, and R.G. Hurriyah. 2007. Growth, nutrient uptake, and quality of turfgrass at some dosages of mycorrhiza application. *Bul. Agron*. 35:142-147.

Junaedi, A., A. Wachjar, and A. Rahman. 1999. The effect of biofertilizer on the growth of young coffee (*Cofee canephora* Pierre ex Froehner) var robusta. *Bul. Agron.* 27:12-17.

Munandar, R. Hayati, H. Adam, Sabaruddin, and R.J. Anjani. 2010. Developing nutrient efficient maize genotypes in marginal land using recurrent selection. Proceeding of National Seminar Polinela, Lampung. Pp. 674-689.

Noor, A. 2003. The effect of rock phosphate and combination of phosphate-solubilizingBacteria and farm yard manure on soil available P and growth of soybean on Ultisols. Bul. Agron. 31:100-106.

Saraswati, R. and Sumarno. 2008. Application of soil microorganisms as component of agriculture technology. Iptek. Tan. Pangan 3:41.

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